WHAT THE GRADUATE SHOULD KNOW.

Paper presented to the Institution, Coventry Section, by J. W. Berry, M.I.P.E., Member of Council, Chairman, Joint Examination Board and Examinations and Research Committee.

WHEN first I accepted your invitation, I had anticipated talking to your graduate section only, but, in view of the fact that my audience includes many who are in controlling positions, I propose to broaden the scope of my talk. Although I am deeply conscious that there are many others who are far better equipped to address you on this subject, I will do my best to put over some thoughts which will promote discussion, and, if any thanks are due to me at the end, they would be best expressed in the volume and quality of the discussion which I sincerely hope will follow.

In answer to the question implied by the title of this paper, I propose to divide my remarks under four main headings: (1) The opinion of the Institution; (2) the opinion of educational authorities; (3) The opinion of industry; (4) methods by which this knowledge can be gained.

The Opinion of the Institution.

The educational side of this Institution owes its inception to the pioneer work of the late Mr. Harry Mantell, and we owe a great debt of gratitude to him, for his work in this direction. A Committee was appointed in 1928, which reported in favour of an examination scheme for graduates, and drew up in outline a syllabus for this purpose.

In 1929 the three technical and art associations were approached, and a conference was held in London in 1929, at which the writer was present. From that meeting, the co-operation between your Institution and representatives of technical institutions began; culminating in the formation of the Joint Examination Board, of which I have the honour to be chairman. Although we cannot claim full credit, I am firmly of the opinion that our efforts have in no small way, helped the growth of technical training for pro-

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duction engineers, for, whilst in 1927 the number of students was 5,367, in 1934 that number had increased to 12,154.

It is interesting to record here the first syllabus, and the first idea of this Institution, on what they expected the graduate to know :—

Works Organisation and Practice.

Part I.—Forms of organisation and their uses. Scientific management, and its application. Departmental organisation. The storing, handling, and movement of materials. Limit systems. Considerations affecting the construction of works, in respect of locality, power, heating, lighting, water, and transport.

Part II.—Workshop drawings. Criticism of design to facilitate production. Machine tools and their uses. Operation planning. Jigs and tools, etc.

Economics and Commerce.

The definition of terms used in elementary political economy. The application of elementary economics to industrial questions. The influence of Home Office requirements upon industry. Employers' federation and trades union regulations. Payment by results. Profit sharing. Co-partnerships and other systems to encourage output. Costing. Control of purchases. The relation between sales and production.

Psychology.

Speed and accuracy of thought. The association of ideas. Power of observation, initiative, and originality. Handling of personnel.

These subjects were to be preceded by an essay which was to be done at home. The main object of this essay, as is the case to-day, was to obtain some idea of the candidate's outlook on industrial life. He was allowed free access to books, and the nature of his essay soon revealed whether he was a man of observation, or a blind reader of technical journals.

It is obvious by comparing the above syllabus with the one in use to-day, that the Institution has extended its views considerably since the early days. They were reluctant to withdraw the psychology item, but the technical representatives, whilst admitting the value of this subject, pointed out that, in the first place, it was difficult to inoculate young people with psychology, in the second place, the number of teachers who were competent to teach this involved subject was almost negligible. Later on, economics suffered a similar fate, and it is worthy of note that, at about the same

time, the Institution of Mechanical Engineers substituted " Works Organisation and Management " for " Economics," in their Associate Membership examination. At the same time the examination was stiffened up. Instead of one day two days became necessary.

At the present time, then, the requirements of the Institution, from the point of view of technical knowledge, are set out as follows : One optional paper selected from the following : (*a*) Construction of machine tools, and jig and tool design ; (*b*) Physical Metallurgy and treatment of metals ; (*c*) The Application of Electricity to Production.

In addition, the following compulsory subjects are included : Workshop practice and processes, Factory Organisation, Planning Storekeeping, and Costing.

Although the fatal word " Economics " has been eliminated, under the heading of " Factory Organisation " and " Planning, Storekeeping, and Costing " the best elements of the original syllabus have been preserved.

The weakness of examinations as a whole was revealed in the second examination that was held. A clerk, who had no factory experience outside the stores office, passed the whole of the subjects with flying colours. In the eyes of the Institution, however, it is necessary that a prospective graduate shall have workshop experience, and, further, that he shall have studied at a recognised college. In regard to the latter, the Examination Board, with the consent of the Council, are now exempting students of approved colleges, after they have completed their full course in engineering production.

The Opinion of Educational Authorities.

I wrote to over 30 educational institutions, and, either my letter was ambiguous or they misread my meaning, for, in very few cases did I receive a real expression of opinion from our friends on the technical side. Maybe, perhaps, one or two of them scented a trap, for they replied that it was difficult to put their ideas in a few words, and would much prefer to discuss the matter personally. In general—*works training*, prior to entering the University or the technical college, is advocated.

Below are a few extracts, which are deemed worthy of comment :

(*a*) Recommends co-operation between the local school and the employer, and submits a syllabus that would cover similar ground to that in our examination.

(*b*) Considers that secondary or public scoolboy should be selected, and that they should work on common ground with students who are taking the ordinary National Certificate.

He goes on to say: "Further—original observation and alertness should be developed by arranging the apprentice beside men of wide experience, men who are enthusiastic about their job—men who have done things, not merely talked about them."

"Further—the training should acquaint one with materials, and production methods, and, above all, give one, if only limited, a knowledge of the world which cannot be obtained from books, or in a closet; a knowledge which, to those contemplating executive positions, is invaluable."

(*c*) A course of study comprising technical details allied to workshop organisation, elementary costing, and industrial psychology. Beyond this, the training should be of the specialised nature according to the actual work of the individual.

(*d*) Here the importance of practical training is again emphasised. After describing the normal National Certificate course, this writer goes on to say: "I have known a number of instances of young men with a university degree feeling rather out of place during their period of pupilage in the workshops, where often they have to do work of a lower standard than youths considerably lower in age."

(*e*) This proposed syllabus boldly suggests economics of engineering, advanced course in works management, production costing and estimating, in addition to the ordinary National Certificate.

(*f*) Pre-supposes a secondary school, with knowledge of physics and chemistry. Following this—a sandwich scheme, which operates as follows: During the college session, the apprentices spend eight weeks in the college, and eight weeks in the works, alternately. They reach degree standard at the end of two years. They learn to work hard, and do not fall into slack habits through having long vacations, as is the case with many students at the universities.

The Opinion of Industrialists.

Here in response to some 20 odd letters, I failed to draw (except in one case, and that a government department), a short expression of opinion as to the requirements of industry from a youth of eighteen plus, who was to be engaged to take up an executive position on the manufacturing side of industry.

In all fairness, let me say that in some few cases I received a friendly response enclosing particulars of their apprentice schemes, but these, I think, would be better dealt with at a later period.

In regard to the one definite reply—this authority states: "It is desirable that the graduate should have a suitable theoretical training in the classrooms, accompanied by practical experience in the works and drawing office, and by courses in metallurgical,

electrical, and engineering laboratories ; also by lectures on phsychology in respect of industrial workers, systems of payments by results, and practical acquaintance with the more common machines used in engineering workshops."

Method of Training.

The method by which the graduate may attain to these requirements is one that gives rise to controversy. There are, at the present time, some 36 colleges which are acknowledged by the Institute of Mechanical Engineers for National Certificate endorsement in works organisation and management. It is fairly safe to say that the majority of these are putting on production engineering courses, suitable for training prospective candidates for our examination. Speaking to a prominent college principal from the Midlands, I gathered that every major technical college has, or is arranging for, a course distinct from the National Cerificate course, arranged essentially for production engineers Further—that the tendency in larger colleges is to run parallel courses with sub-divided instruction, thus allowing separate schemes for executives. On the whole, the standard is not yet up to that of the ordinary National Certificate, the main trouble being that highly qualified people are difficult to find, and, even so, tend to glorify their own particular interest rather than to instruct on broad principles. Production men, with a wealth of wide experience, tend to stress knowledge of another field, with which they are not sufficiently familiar to put over to a class of students, rather than to arrange scientifically the matter in which they are expert.

There are, apart from a full University training, four main methods by which technical knowledge may be obtained :—

(1) The evening continuation school, where the student spends three nights per week at the college, and possibly two other nights doing homework, after his normal day's work.

(2) He may, by arrangement with his employers, spend two half-days per week, and one or two nights per week, along similar lines.

(3) The sandwich course—whereby the student spends six months in the technical college, and six months in industry. At the end of the four year's course, he should be in a position to take his final engineering degree, and will have the advantage of the equivalent of two years' works training.

(4) He may sign indentures with a suitable firm, with or without premium, whereby technical training is included as part of the apprenticeship scheme. In this connection, there are one or two very fine schemes in operation at different works, and a brief reference to these is not out of place.

One organisation offers the following :—

A trade apprenticehip course for artisans, inclusive of a works' school; training for professional employment for boys leaving secondary schools, allied with training at a local college; a college apprenticeship course for those having obtained a university degree. Further—facilities are offered for university students to take up practical work, during their long vacation.

Another works offers a scholarship course, whereby the students are selected from various colleges, and given a three-year course in the works, paying a living wage during this period.

A third firm offers an alternative of three, four, or five years' apprenticeship, facilities being given to attend a local college during the day-time. In this case, a heavy premium is required. In addition, these facilities are offered to selected students from the local colleges, in the form of Scholarships.

A fourth firm offers similar facilities to No. 1, and they also grant a special award to apprentices obtaining an engineering degree, in the form of a maintenance allowance, with facilities for visiting U.S.A. to obtain experience in associate works.

A fifth firm offers apprenticeships of three or five years, and co-operation with the local technical college ensures an adequate technical training. In addition, they accommodate the "sandwich" apprentice. It is interesting to note from this firm that quite a number of the apprentices of all grades have tried, or are preparing to try, for our graduateship examination.

A sixth firm, in addition to the ordinary apprenticeship scheme, have a special arrangement for students between the ages of eighteen and twenty-five, who have completed their technical training, to obtain an all-round knowledge. Every fourth month, they submit an essay on the work done, and are asked to make suggestions. They must, of course, avoid personalities, but they are encouraged to be critical of facts and processes.

A seventh firm offers an alternative course, according to the particular taste of the apprentice, after a six months probationary period. An apprentice committee and a supervisor look after the interests, and to an extent the discipline, of the young aspirants. They have a works' school, which is supplemented later by attendance at the local technical college.

No 8 offers similar facilities, but states quite bluntly that premiums are considered "immoral."

The schemes enumerated above are excellent and, whilst admitting that they do not represent the whole story of the interest which many firms are taking in the training of your engineers, they leave much to be desired, and I state quite frankly that this country is seriously lacking in its efforts to train engineers, and skilled men of every description. The industrial problems of the future tend more and more towards one major problem—that of personnel, and

the more mechanized industry becomes, the more definite will the problem of personnel be a ruling factor in the successful management of a business.

It is my considered opinion that to ask, or even to expect the youth of to-day to spend three nights per week, plus homework, after his day's work, is approaching very nearly to exploitation.

I do not suggest that we should go quite so far as our Continental friends, but I do insist that it is time that we took a broad view in regard to our employees. Without waiting to ask ourselves if we are paying for the education of a youth who may get a job somewhere else when he has finished his time, we should take a national view, and our object should be to turn out the best possible craftsmen.

Let us hear what educationists have to say on this point. Here is one opinion : " The local employers in engineering do not liberate apprentices during working hours. In this respect they are retrograde, since all other trades, e.g., builders, chemists, etc., get one or two half-days per week. Were I to start my thirty-five years' course over again, I should put all the emphasis on part-time and full-time day classes."

Again,—" In reply to your letter on the 29th, my experience is that the most successful form of technical education is the part-time day one."

There is another aspect of this problem. The teachers are not in the best condition to impart knowledge, at the end of the day. Further, many technical colleges are overcrowded at night, and empty during the day-time, and this means that part-time teachers have to be engaged to carry the burden.

The Board of Education, quite rightly insist that for a full-time teacher to obtain the necessary hours to qualify for a pension, he must have a minimum number of students in all his classes. This results in the grouping of classes, and I know of a case where students from an intermediate school, part-time apprentices, and students studying for Intermediate B.Sc. degree are all grouped into one class. The percentage of evening students to day students, in production engineering, is approximately 16 to one. This is all wrong. I put it to you, as men keenly interested in the economics of plant and buildings (apart altogether from ethics), do you consider it economical for plant and buildings which have cost upward of £150,000 to be fully occupied for only ten hours per week ?

I was very much amused the other day, when reading of the general election taking place in India, where it is impossible for the candidates either to see, or to be seen, by the whole, or even by a mere fraction of their prospective supporters, and as most of the latter could neither read nor write, they had no means by which they could put their views in front of the electors. This being

so, they adopted symbols, a banana, a melon, or so on, and the electors voted for their favourite fruit.

I submit to you that, to a large extent, the average man who pays his education rate has no more knowledge, or thought, as to how the money is spent, than these poor illiterates had of the views of their prospective representatives.

I further submit that one or three phases will develop within the near future :—

Either : (1) Industry will take a more active interest in the technical education, not only of their executives, but of their artisans ; (2) the government will take it into their hands to compel employers to include a scheme of education in their programme of training ; or (3) we shall fall very heavily from our present high position in the field of engineering.

This latter statement may seem to you to be an exaggeration of the possibilities, but let us examine what is being done on the Continent.

In France, they have what is called an " Apprenticeship Tax " levied on all firms having a wages bill of more than £100, which brings in upwards of £2,000,000, the whole of which is added to the technical education fund. They have industrial schools, where boys are actually taught a trade before entering industry, and the boys enter these schools from the age of fourteen to sixteen years, and remain there for four years, working from forty to forty-four hours per week.

In Belgium, they have at Charleroi an Institution called " The Industrial University," which will accommodate about 1,000 students.

In Germany, a student in the first two years learns theoretical foundations, i.e., mathematics, mechanics, etc., and, after an intermediate examination, he has to design a machine tool, enter the machine tool laboratory, and find the best methods of manufacture, calculate manufacturing costs, etc.

In Italy, their preliminary instruction has been reorganised on the basis of " The Scientific Management of Works," and is aimed at establishing a direct link between the economic life and the school, in the preparation of working citizens, and also to give all young men a professional education based on technical knowledge, and in technical and practical ideas. The selection of a profession is not left solely to the decision of the individual, but is governed partly by psychological tests. Having decided on his profession, he is subjected to intensive training.

This method is adopted in Germany also, and schools have been established which lay particular stress on methods of production.

In Switzerland, they have special courses for foremen and chiefs, " leaders' courses," as they are called. Comments on their experi-

ences from these courses are interesting, but time does not permit of repeating them here. I would, however, recommend all interested to study the Educational and Training sections of the Sixth International Congress of Scientific Management.

In Sweden, following the Labour Peace Committee of 1929, an Institute for training labour Managers was inaugurated.

In India, The Tata Iron and Steel Co. financed the equipment of the local Technical Institute, and, by the technical training of natives, have become almost independent of foreign labour, even for the highly skilled technical positions in their works.

To summarize: The training for Graduateship should aim at giving the candidate a broad outlook on engineering production problems. It should avoid specialisation. His training should give him a knowledge of materials and their manipulation; of the problems involved in that manipulation, not only physical problems, but also what is equally important to-day, with our large quantity production, the orderliness of flow; prompt and accurate costs; precise, but yet restrained, inspection, etc.

I mentioned the term "broad" deliberately. It is absurd to expect a man of the age of twenty or twenty-one years to be an expert, even in the few phases enumerated above, but he should be acquainted with the importance of these factors, and with the methods by which they may be obtained.

I would lay the greatest stress, however, on the importance of practical training. It is only by this means that a graduate can obtain the correct attitude to the artisan type of mind, for, no matter how brilliant a man may be, unless he has the capacity to get on with his fellow workers and subordinates, his future career will be marred by unpleasantness, and possibly—failure.

Now, a word to the graduates present. I was being driven in the North of England some two or three months ago, and, whilst ruminating on what sort of framework to construct this address, my eyes fell on a wayside pulpit. On it were these words: "He who builds to many mens' advice will build a crooked house." My immediate thought was "by what right has this Institution asked many men with different shades of thought to interfere with the graduates' building problem?" Then I thought again—"we cannot build for you, *you* must build. Our responsibility ends with advising you on planning."

Here, then, is my advice to you. Firstly, be convinced that you are suited to the work, that you can stand up to the knocks which will be your lot, and that you can go on working with interest, even though your chief is not paying you what you think you deserve. Some day, if you persevere, you will be able to demand your worth, and, perhaps, tell that former chief what you think *he* is worth. The leading men of the future will be those who know

more than their colleagues, and, what is equally important, those who know that they know, not in an arrogant way, for arrogance is not born of knowledge, but of *fear*, in its worst phase.

Talking of fear, a famous psychologist claims that fear is an instinctive emotion of man, and, if properly controlled, is a good thing. In the field of sport, it urges us to do our best, for fear of being beaten. In our daily task, it urges us to take care, for fear of making errors, and to do our best, for fear of being superseded. Confidence, born of knowledge, and correct training, is the attitude of mind of the man who knows fear, but knows his own power to meet the situation.

Read the pamphlet issued by the Institution of Production Engineers, which was drafted by your very good friend Mr. Groocock, then—plan your career, then—work. Having done this, you need have no fear for your future.

I put this question to a Scottish member of Council at Glasgow, last December, having first explained to him the purpose of my query, "What, in your opinion, ought a graduate to know?" He paused for a minute, then replied "Tell them to learn how to listen." With this pregnant thought I will finish, thanking you all for the patient way in which you have listened to me this evening.

Discussion.

MR. DRANE : Mr. Berry mentioned how a young fellow should start in life. I have always been interested in that and been asked the question many times of whether a young boy straight from school should first of all have some technical training or whether he should go into the works. I think Mr. Berry favoured the latter—putting the boy into the works, then giving him some technical training and finishing up, perhaps, in the works in an executive position. My views have been the reverse. I have felt that a young fellow leaving school, without the advantages that some of us have, sees life from an entirely different angle. There is such a big difference between school and workshop life that I always think it better for him to have a technical training in the drawing office, say, for a few months and then go into the works. That point was just in passing.

I was also interested in the apprenticeship tax. Does the firm pay a tax on each apprentice they have ? If so it might bar a good many firms from taking apprentices. In Switzerland you mentioned that foremen and chiefs attend classes. How do you think that would work out in this country ? I was going to say it is bad enough to get graduates to come along.

Also, I have often noticed—and it is a point that always comes up—one of the first things the majority of people with sons starting out to work think of is how much money he is going to get. I heard of a case this week of a boy earning in an engineering works 17s. a week, but his parents thought it was not sufficient for a boy of sixteen, and so he left to do something else. The worst case I know is that of a young boy whose parents were doing everything they could for him ; all he did was to make tea for the others ; from there he was a butcher's boy ; then he went into the drawing office ; and now he is in the Army as a drummer boy. This is a case that makes you think.

Regarding the case system. The graduates in Coventry had this down on their syllabus, but I think if Mr. Berry ever has an opportunity of seeing the case system he will agree the importance of seeing that it is presented to any of our sections in a manner which can be understood. We here in Coventry had a foolscap sheet, stating the case, and although we argued about it for more than half an evening, when the lecturer presenting the paper at last arrived we found we had been discussing the wrong aspect of the case altogether.

MR. BERRY : The Apprenticeship Tax is not based on the number of apprentices, but on the turnover of the works.

MR. DRANE : Suppose the firm hasn't any apprentices at all ?

MR. BERRY : They still have to pay the tax, as it is a tax on industry.

There is an objection to the French scheme. It is that an apprentice is selected and his life is mapped for him. The chance of rising is very small indeed because the school is graded. I was in France ten days ago and I discussed this question with a gentleman whom I met there. His experience, going back a few years, is contrary to the general opinion held in England of the French system. He started life as an artisan ; he joined a firm, then went to an arts and crafts school—equivalent to one of our universities—and he is now the acting manager of a very large works in France. The man who was his boss when he was working at a lathe is now working for him as a foreman in the works he is in charge of to-day.

I cannot help you at the moment with the case system, but I agree the question of parents is a bit of a nuisance—it is a pity we cannot pick our own. My ideal form of training is the " sandwich " system. In my opinion technical qualifications, whatever they are worth, are going to be more important in the future from the point of view of getting executive positions. My own boy is going through his training now on the " sandwich " system. He has matriculated, and now works from June to December in a factory and from January to June at a college. By that means he is marrying his works experience with his technical training, and his mind does not become lazy on the long vacations usual at university. Having attained his degree at the age of twenty, he will have two years' practical experience behind him. As regards the apprenticeship scheme, there are a number of works in Coventry running very good apprenticeship schemes, where boys can have time off during the day for part-time attendance at the technical college.

MR. BUTLIN : I am sure we are very much interested in Mr. Berry's paper ; it is the sort of paper which I should have preferrred to read over first, because there are a number of things I could have referred back to and books I have at home which I should like to have consulted. The paper raises a number of controversial points. For instance—psychology. Our first contacts, our earliest conceptions—all really a question of psychology. How we got on wth the lads we played with—the whole thing is human relations, and yet it is left until we get to what I consider an advanced age, from the point of view of education, before psychology is actually taught and explained to us. (Probably because there are not sufficient adequately trained teachers—I don't know). You suddenly find that although you were able to get along with school-mates, you now have to handle people in a much more delicate manner and a new technique opens up. The question is raised, should we not teach psychology at an earlier stage ?

It was my good furtune to go on a students' apprenticeship

course with a company in America. They had an arrangement whereby they took on selected men—by that I mean useful men for a factory training course. They gave them an introductory six months in the works, followed by the essay principle, then the moves were more or less left to the individual. The student might only be in a small department for a fortnight and get a glimpse of the general methods and technique. Then he might take up a position as charge-hand for a week or so. Another feature was that they paid a living wage. I think there is a lot in this question of money. I have had certain shop lads working for me having perhaps 8s. per week, plus a bonus, bringing it to 12s. To a town lad that does not seem much because he might go somewhere else just as easily and get more. Don't you think lads of a certain age, doing a certain grade of work, should be paid something like a comparable wage, so that you don't get lads gravitating from one trade to another because they can get 2s. more?

This raises the question of psychological tests. I don't know whether Mr. Berry agrees with them. At the American works I entered, they made a point of testing their students at the beginning of their course and examined their records at the end, which gave them a chance of correlating the tests with actual experience. I would like Mr. Berry's opinion of this.

Mr. Berry's remarks on fear were interesting. I have been reading a book on psychology and this touched on fear. Everyday reactions were put down to fear to a certain extent,—fear of being made fun of, etc. Fear seemed to be at the bottom of most of our actions. In fact it went so far as to say that the reason we laughed at certain situations was due to fear of not seeing the thing in the right light, and fear of being criticised.

MR. BERRY: The question of early teaching of psychology. Actually, it is thought of early in life, in a mild form, i.e., the very organised games children are taught, etc., but to teach the fundamentals of psychology to a youth whose mind is not perfectly balanced is a fatal step, because the youth would either become very quiet and self-contained, or, depending on his mental make-up, boastful and self-opinionated. Within limits, I think there is something in the application of psychology, but there again it is a question of experience and only firms who have taken the plunge—like the one you mentioned in the States—and the Institution of Industrial Psychology, who in spite of the remarks that are made against them are doing very good work—can prove there is a very great deal in the application of psychology.

MR. DRANE: Could Mr. Butlin tell us how the tests that were taken compared with actual experience?

MR. BUTLIN: They give you a certified grade according to the results of tests in, say, mechanical aptitude, mechanical experience,

memory, vocabulary, etc. They put you down as "extravert" or "introvert." I was graded as an "introvert" and at the time I disagreed with their findings, because I got on well with my fellows, I was not of the research type at all—I had gone on to the manufacturing side. Another test they made was for finger-dexterity, and then they gave a list of jobs in which my aptitude would serve, and they said that my chances of success at progress work, say, would be only 60%, and what possibilities of success there were for me in any particular job.

MR. BOYES: I agree with the previous speakers that it has been a very interesting talk and has opened up some interesting points. I should like to thank Mr. Berry for his very nice way of putting matters as regards psychology. I think all fellows should take it up at some time of life. It is almost like stamp-collecting to a schoolboy; he takes it up at a certain period and in some cases drops it almost as quickly. The Institute of Psychology is doing some very good work and they have a good field before them. The trouble is that there are so many amateurs at it that they spoil the field for the rest. I had a good example of this before me not long ago. A party of boys were being trained from the psychological point of view. The boys just knew they were being watched, and they were examined periodically on the points our friend has just mentioned. At the end of a given time they were tabulated. I and some others examined the list. We were told that they were going to follow the employment for which they were best suited. About six months later something crept out which, perhaps, should not have done. All the boys had found employment except one—most of them through parental influence and not on merits at all. The one boy without employment was actually the boy who had come top in the tests. I am not pointing out the weakness of psychology, but the fact that when it is handled by amateurs they don't get the benefit out of it.

Mr. Berry pointed out to you that it was considered a little interfering on the part of the Institution of Production Engineers to take up this attitude in education. I have had that pointed out to me many times. I speak in support of Mr. Berry from this point of view, that education in the past has grown from the early church where the priest gave the edu ation and from that until the present time what you might call the t eorists have had the field, and it is not many years ago—about twenty-five—when industry was called upon to assist with education from the point of view of training the national life as well as improving the industry.

I was called before a party in London, and after the real business for which I was there was finished with they turned to me and asked what were my suggestions on various points, and it eventually came to the training of young people from the engineering point of

view. I was not up before the party for that purpose, so, thinking "I am a free-lance here; I can say what I like," I told them "You are a party of directors from the educational point of view and I plainly state that if you don't look out for education somebody-else will—industry will!" They pulled me up to point out some cases, and I mentioned one or two firms that were already doing it. This was brought to my mind when Mr. Berry said that the factory school was not very popular.

Mr. Berry pointed out that these schools were narrow-minded in that they were training their boys to manufacture their own firm's goods, whereas if the students go to technical college they can have really good discussions with students from another trade, taking the case system and discussing it to real advantage.

Coventry has stood up very well on the technical college side, but there are many cases from the educational point of view where the training of the production side can be greatly improved, and I think that might be brought about by the greater interest industrialists might take from the general manager down to the chargehand—and from the point of view of considering the lower rank, chargehand, that is a very important point for the student.

A great problem is the overtime system. Permission is sometimes given to the student to attend the evening classes, but whilst that permission is given officially it is very often interfered with by one of the members of the junior staff. One works I was round a few years ago have an objection to part-time education and will not allow their apprentices to go to a part-time class. They say they cannot run their works by allowing the students to leave during any part of the working day. The foreman objects—it is a loss of revenue for him—and also the other members of the gang, if work is done by the gang-system.

I was also interested in Mr. Drane's comments on the tax on apprentices.

Though I must apologise on behalf of the Coventry Section, as this is a very poor attendance compared with some others, I do make this appeal to the members present that they do what they can to help the young fellows in the shops by recommendations, by suggestions. Speaking now as one of the staff here, we get fellows coming at nineteen and twenty years of age with no knowledge at all about the Graduate Examination. There is also another grade, i.e., the first class examination, where a student can gain a great deal of information which will help him even if he is going to do nothing more than be an ordinary draughtsman. With a couple of years' elementary training, students gradually get over the fear "I can't do it"; they have more confidence in themselves and a little more recommendation will often be sufficient and will even teach them the value of Mr. Berry's quotation "Tell them to listen."

MR. BUTLIN : A point or two which came up during Mr. Boyes' comments. He mentioned the lad who " came out top " in the tests. You surely don't come out top or bottom in these psychological tests ; you are at a certain stage where you might become an efficient salesman, or at another stage where you might be an efficient craftsman ; you can get to the top in your own particular sphere. I have always considered psychological tests to be a pointer rather than an examination scale.

In regard to parents leading fellows into a job, some people try to discourage, others try to drag them in afterwards. It is my experience that that influence is helpful to a lad in starting in the first six or twelve months. The fact of his father being in the same trade, etc., is of some help, but after that he might just as well have gone in on his own, and must stand on his own feet. That, to my mind, is where the mistake lies in being directed by one's own parents.

On the question of part time training, I personally support Mr. Berry on the value of attending the part time classes. From my own experience I know you can get very much behind in home-work.

MR. BERRY : There is definitely a lot in parental guidance, but we as an Institution should be prepared to replace what is very often lacking in parental advice.

SOME ASPECTS OF MANAGEMENT.

Address to the Leicester and District Section by the Section President, J. H. Bingham, M.I.P.E., M.I.Mech. E., M.I.Chem.E., Chairman of Council.

HAVING regard to the prominence which is likely to be given in next session's programme to papers dealing with matters of a managerial nature, I have decided to make this an opportunity for addressing you on certain aspects of the management function and so provide a foundation or groundwork in readiness for the detailed treatment of the specific aids to and instruments of management.

The Industrial and Social Responsibility of Management.

I will begin by tracing the historical changes lying behind the gradual development of modern management, which is the outcome of the concentration of men and machinery. With the old domestic system businesses on the whole were small and management was owner management. The nineteenth century brought its changes. One of the outstanding features of industry during this period was the growth in size of business units. This was made possible by improved finance facilities, resulting from the reorganisation of banking, which was established on firmer foundations and enabled industrialists to enlarge, and by the accumulation of capital.

It was in the year 1833 that the principle of limited liability was established and legalised. Prior to that date, the amount of capital available for a business undertaking was limited to that possessed by the owner, with the addition of any introduced from other sources on his own personal guarantee.

This limitation of capital, coupled with unlimited risk, restricted development and enterprise. With the advent of the joint stock system, providing, as it did, facilities for increased capital with distributed and limited risk, the obstacles to expansion of industrial units were removed, but the system brought with it also a change in the type of ownership of the units. No longer were they owned by the single capitalist managers but by numbers of capital investors who had no share in the actual management of the units and whose only interests were in the returns which their investments brought to them. However, industry flourished in this country until the eighties and nineties of last century, when there was a great trade depression, due largely to the rapid technical advances and growth of industry in Germany, Japan, and the United States

of America. Previous to this we had no rivals, and therefore there had been no competition. British industry was now faced for the first time in its history with severe competition which led to combination and trustification, and the problems of management became intensified still further.

Passing over a few decades we come to the Great War period, involving an industrial revolution in itself, at the end of which the world found itself in industrial competition to a greater extent than ever. Countries previously non-productive were now producers; instance Canada with its iron and steel, clothing, and shoe industries, whereas prior to 1914 it was entirely agricultural. The new trade rivalry was much greater than before, and the response to this was a movement towards rationalisation which brought changes in control with the formation of trusts, mergers, holding companies, etc., and also changes in method. The latter were the more extraordinary. The application of scientific methods in industry resulted in changes in production and social features, and created managers of an entirely different character.

The function of the manager to-day is just as distinct as that of the engineer or the accountant. He is now set against an entirely different background from that of a century ago, which was one of individualism. To-day the background is coloured by the interest of the public in industrial affairs, as evidenced by the proportion of newspaper matter taken up with that subject, and also by the conversation of the man in the street. It is affected by a new conception of work, which is now for service and not primarily or solely for profit. It is coloured by the spirit of association between manufacturers who meet to discuss common problems, secrecy being no longer of paramount importance. It is coloured by the scientific spirit. The old "hit-and-miss" or "trial and error" system is fast disappearing, as it is realised that there is a scientific approach to every problem. The background is coloured also by the realisation, sometimes an enforced one, of the essential humanity of business. The tendency previously was to de-humanise the machine, now it is to consider the man more than the machine, for the human element is to be the more important. The background of to-day shows definitely the change in the attitude of capital towards labour.

With the old domestic system the owner-manager's responsibilities were personal. The modern managers's responsibilities are fourfold: (1) To capital; (2) to labour; (3) to the consumer; and (4) to the community. I will deal with each of these in turn.

The responsibilities towards capital are obvious. The shareholders expect a return on their money. Consequently they are inclined to judge the standard of management by the size of the dividends which they receive. This gives rise to many problems

for the manager. Before taking any step he must consider the immediate effect it will have on profits. The shareholder, to-day, fortunately is content with a good average market yield ; so the manager has to watch that the investor does not lose his money and that the yeield is up to market average.

For an estimation of the manager's second responsibility let us consider the extent of state interference with regard to labour. The state stipulates and deals with minimum requirements, but there are certain responsibilities which it does not undertake. For example, it is the responsibility of the manager to maintain as far as possible continuity of employment for his personnel. He should aim also to provide working conditions better than those which are made compulsory by Home Office regulations. Wherever it can be done, medical and welfare services should be instituted for the benefit of the workers. Such services are calculated to make for greater efficiency although they cannot be measured in terms of profit and loss.

Now we come to the responsibilities to the consumer, and these cause an interesting turn of the wheel. In the middle ages it was considered immoral to cheat or swindle the customer, but gradually the principle of *Caveat Entor* (" Let the buyer beware ") crept in. Nowadays, however, the manager realises that he must not take advantage of the ignorance of the customer, for with the great variety of wants the buyer cannot be the judge, and he relies there ore on the representations of the seller. Management's obligations to the community have emerged in tragic form during recent years as there have been several instances of the closing down of large industrial concerns such as those at Penistone in Yorkshire, and others in South Wales, which have brought disaster to the local communities.

The Analytical Approach to Management Problems.

This heading is somewhat ambiguous because analytical approach is really management. It is true to say that modern industry started in Great Britain, which was extraordinarily rich compared with other countries, but it was inexact in its early days. Many " hit-and-miss " and " trial and error " methods were employed, and there are still some concerns to-day where management, in the sense in which I use the word, is not recognised, and guess work is common. Fortunately, however, modern industry has acquired an exact technique, and on the production side of the majority of trades it is an exact science. One of the earliest to practice scientific management was Frederick Winslow Taylor. He applied the intellectual principles acquired in the study of the sciences dealing with materials to the task of conducting business viewed as a whole. He says in his published works : " When men whose education has given them the habit of generalising, and everywhere looking for laws, find themselves confronted with a multitude of problems, such as

exist in every trade, and which have a great similarity to one another, it is inevitable that they should try to gather these problems into logical groups, and then search for some general laws or rules to guide them in their solution."

We can trace, as Taylor recognised, an evolution in business practice similar to that which has occurred in medicine, and there is already a claim that the conduct of business enterprises should be regarded as a profession. The primary difference, however, is that business men have to deal with other human beings, and the difficulty here is that psychology, the most helpful and hopeful of all the sciences in this connection, is in an early stage of development.

Engineering was the first branch of specialised knowledge to be affected by the application of scientific knowledge to the problems of production. It is itself dependent on the advance in the sciences of mathematicss and physics, but it was recognised also that there is another group of sciences which bear upon the human factors—the men and women employed in production. Instance the havoc wrought by disease in the early stages of the cutting of the Panama Canal. It was only the enlightened use of bacteriology and physiology which solved the problem. Now we have experimental psychology suggesting a host of new possibilities in the handling of individual workers and in developing those incentives to effort on which co-operative economic enterprises ultimately depend for their efficiency.

I have no doubt that many of you have already framed in your minds the questions, " What is meant by scientific method in management ? " and " How is the scientific approach to a problem to be carried out ? " It is obvious that the first thing to do before tackling a problem is to ascertain what the problem really is. If a manufacturing programme is being contemplated, for example, the first question to ask is, " How much of the potential demand for the particular product can our resources and organisation secure ? " The question of large policy cannot be answered until it has been analysed into its constituent problems. After this has been done it is helpful to find out what other people have done on the subject, although this is not always easy to ascertain. Towards this end, however, one should make use of every contact possible, taking care that time is not being wasted, and seek out all the information that is wanted. Anything having a bearing on the subject should be noted, after which, all that is significant should be classified.

Management Research Work.

What has been suggested is really research work, and, as aids to this, use may be made of the research institutions available for the purpose. The chief of these, the Government Department of

Industrial Research, is at the service of British Industry as a whole. The important work of this department is the investigation of the properties of raw materials which are embodied in reports available to the public. In addition, there are research organisations subsidised by the government, and devoted to particular industries. These organisations, about thirty in number, of which the Non-Ferrous Metal Association is one, delve deeper into specific problems, and consider also questions of design and manufacturing methods. There are also several private research corporations from whom information and assistance can be obtained. The National Institute of Industrial Psychology, for example, is an organisation which derives its income from subscriptions and fees and conducts research for the most part into the personnel side of industry. It will offer assistance on vocational selection and will also advise employers regarding these matters. Management Research Groups is another organisation doing excellent work for the firms attached to it. Mention might be made also of the London and Cambridge Economic Service, which provides personnel for making investigations and for examining economic data with a view to forecasting tendencies for businesses for the near future. Some of the large individual concerns have research divisions of their own, but they are mostly technical. Those of the Imperial Chemical Industries and the Central Electricity Board are outstanding examples.

The problem of market research is perhaps the most difficult of all, as the maintenance of market research divisions by individual companies is very expensive and only the largest concerns can afford them. Many undertakings and industries made use of those maintained by the important advertising organisations. It is no doubt true to say that the most definite example of analytical approach in modern industry is to be found in the development of the outside consultant, who employs what is known as the " Why Technique." Why is this done and why is that done ? When such questions as these are asked attention is often focussed on antiquated and unsatisfactory methods. For example, the institution of regular rest periods during the working session was the outcome of someone asking " Why is work carried on throughout the session ? " " Why not try the effect of the introduction of a rest pause ? "

Recently also there has been set up a British Management Council supported at present by about thirty institutions and associations interested in management problems. Our own Institution is represented on this Council.

The Delegation of Responsibility.

The most important thing about delegation is universality. It is met with everywhere, and the ways in which it shows up in various organisations are interesting. Consider the case of the

Roman Catholic Church, where the conception is that the Pope holds from God complete control of the Church. As he is unable to exercise this control himself there is a direct line of delegation downwards from the Pope. There are similar conceptions in the other churches, as well as in the state, and the idea of delegation is a very old one. In the case of a republic, France for example, we have a centralised delegation downwards, the authority being thrown inwards first from the people to the head of the government. The classic example of delegation is, of course, that found in military affairs, and it is from military procedure that we have definitely learnt the theory of delegation. A good example of delegation may be found in Exodus XVIII, from verse 13 onwards.

In that you will find mention of ordinances and laws, which may be likened to the policies ; the instructions to make plans in the words " Thou shalt show them the way wherein they must walk and the work that they must do " ; and the request to bring the " hard causes." How to ensure that the latter are brought to the delegator is a matter of great importance to which I will refer later.

Turning to industry, which in this country, as I have indicated before, can be divided under two heads, that of individual ownership, and that of limited liability company proprietorship. In the case of the former, there is one head of authority who delegates outwards and downwards. In the other type, the shareholders delegate authority to management, which delegates downwards.

The Implications of Delegation.

As delegation is found everywhere, it is necessary to understand its implications. Without delegation, there could be no question of superiors and subordinates. The delegation of responsibility entails the delegation of authority and this must be of the same nature as that which the delegator himself would have if he were to do the job. Remember, then, that responsibility alone cannot be delegated ; authority must accompany it. There are two essentials to consider. First, the necessity of conferring authority for the carrying out of the specific duties, and second, the necessity for laying down, in absolute detail, the limits of any man's responsibility so that there shall be no over-lapping. The provision of management and organisation charts will facilitate this. Such charts represent the hierachy of the staff of the concern, and show each man's immediate superior and subordinate ; they are a sort of photograph of the structure of the organisation at a particular instant.

It is necessary to arrange that an individual shall receive his instructions from one person only. Dual command must not be permitted, as this is the source of a great deal of friction, but it often occurs through small defects in organisation, which a chart will

reveal and enable one to avoid. Closely allied to the question of unity of command is that of the number of people to report to one individual. Theorists say that one person cannot efficiently control more than ten others, for in order to do his job properly he should be able to spend time with each one and in addition he should have time to spend on creative thinking. Another aspect of the problem is that of the amount of detail which one can handle satisfactorily. Experience shows that in many trades a foreman, with assistants, can control from 30 to 40 operators.

Although responsibility is delegated it must be remembered that the delegator is ultimately responsible, for though a delegate derives responsibility to get certain work done it does not necessarily go beyond him. When delegating responsibility and authority, instructions must be given which are specific enough to ensure that within certain limits the work shall be carried out in a certain way, but they must not be so limited as to kill the initiative of the subordinate.

A line of delegation is never very long. It is usual to find a line of four to six steps, and never of more than six or seven steps, except perhaps in governmental organisations where there may be as many as ten. In cases of sub-delegation, the delegator's authority is conferred downwards along the line, but there are exceptions to this. Sometimes a delegator may appoint a delegate but the power given is not always to be passed on. For example, a sales manager may control several sales areas, but the district managers may receive their appointments direct from the board of directors. Everything depends on the law of the particular situation, but in any given set of conditions, if the information is complete enough and the policy known, there should be no possible argument as to what is the correct course to take or as to where the authority begins and ends.

Some people delegate everything, or if they do not, they would like to. There are others who cannot delegate at all, for they believe in the saying that " If one wishes a thing to be done well, one must do it oneself," consequently they attempt to do everything. If one of the latter type does delegate, through pressure of circumstances, he still wants to control, with the result that the delegate is robbed of all initiative. The ideal is the man who does not delegate too easily, but does so immediately he finds the work on hand too great. At such times he decides just what work he wants to delegate, and just what responsibility and authority he will delegate with it, recognising when he does this, that he cannot delegate his own ultimate responsibility. There are also good and bad delegatees, and the latter are those who fail to " bring the harder causes." The good delegatee is one with initiative who is ready and willing to take all the responsibility of his job but is able to recognise when he sees in it a problem which involves a matter of

policy which he himself is not in a position to solve, and having done so does not hesitate " to bring the harder cause " to the delegator.

Delegation and Initiative.

On the importance and value of initiative I cannot do better than quote Henri Fayol who says : " The success of management depends to a large extent on the development of initiative in the subordinates and this can only be done by giving them as much freedom as their positions and abilities will allow, even at the cost of a few mistakes, the importance of which can, moreover, be reduced by careful supervision. They should be guided discreetly without doing their work for them, they should be encouraged by praising them at the right time and by making a few sacrifices of pride for their benefit. It is in this way that men with latent abilities can soon be transformed into a first-class staff. On the other hand, an absent minded and careless greeting, or the rejection or indefinite postponement of every proposal soon dry up the sources of initiative and loyalty. It does not take long for good or bad management to change the outlook of a staff."

FACTORY PLANNING AND EXTENSIONS.

Paper presented to the Institution, Luton, Bedford and District Section, by W. Puckey, M.I.P.E.

I AM speaking to you this evening not as an architect with a smattering of production engineering, but as a production engineer who, in the course of his normal job, has to possess—among many other activities—a limited knowledge of architecture and surveying. I shall, during this talk, dwell on certain aspects of the two latter professions, only to the extent that they influence the production engineer's outlook on factory planning, as it is obvious that I cannot, through ignorance of the subject-matter, enter the field of the architect during either the paper or discussion, neither do I propose giving tables of such information as lighting values, floor loads, etc., which can be obtained from various text-books.

Many people imagine that an architect will, on demand, produce complete plans and specifications for a factory, choose the site, and build the factory for a client. Well, no doubt, many factories are built this way, but the main object of a factory is to produce therein the product required, and the production engineer, who has to live in it and get results should, if necessary, press for full consideration of his point of view before even the site is fixed.

I would, however, emphasise that in all fairness to the company and the architect, the latter should be called in at the very early stages, as much money and time can often be saved by getting the architect's specialised point of view on such a question as choosing the site.

It may not be generally known that many architects work in groups, containing specialists in such matters as site choosing, negotiation for purchase (often much more expensive if the principals deal direct or are known), pure architectural work, consulting engineering, etc., thus giving complete service from beginning to end, and, although no doubt each will get, in common parlance, a "rake off," the combination of effort and results may justify it. I shall deal first of all with factory planning, and later more specifically with extensions, but it is obvious that to a large extent many points to be discussed under one heading would also be equally at home under the other.

Now, when you consider factory planning, you usually start off by considering a suitable site. What factors are likely to influence you? Fig. 1 may help you, and shows a representative list of questions you should ask yourself. They are in a rough order of importance.

FIG. I.

CHOICE OF SITE—FACTORS INVOLVED.

(*a*) PROXIMITY TO SELLING MARKETS—Prompt delivery.
(*b*) PROXIMITY TO SOURCES OF SUPPLY—Prompt delivery, personal contacts.
(*c*) TRANSPORT—Proximity of railways—main roads; canals—river—sea; airport.
(*d*) LABOUR—type—proximity—transport—trade cycle in relation to other local industries.
(*e*) ELECTRICITY—Local supply cost and restrictions. Own generation. Voltage in relation to existing machinery.
(*f*) GAS—mains—natural—generate.
(*g*) WATER—natural—mains—wells—drinking water. Hard or soft.
(*h*) Topographical features of site—foundations—levels.
(*i*) Sanitary provisions—sewage—public or private disposal.
(*j*) Build or lease—comparison.
(*k*) Expansion possibilities—spare ground
(*l*) Local Regulations—building by-laws—labour regulations—storage by-laws—town planning—waste disposal
(*m*) Social and sports possibilities.
(*n*) Advertising value—adjacent to rail—roads—sea—air.
(*p*) Fire protection—local brigades.
(*q*) Rates—possible charges of local council.
(*r*) Climate—in relation to products—health of employees.
(*s*) Prevailing winds—possibility of smells or smoke nuisances.
(*t*) Noise troubles—local residents.
(*u*) War-time dangers—proximity to Continent.

Sometimes a potential buyer may decide to ask himself nothing more than "where would I like to live?" For instance, I know of a metal equipment manufacturer who decided to build a factory at a certain seaside resort simply because he liked yachting! Sometimes a considerable amount of luck enters into the success or otherwise of the final choice, unless one chooses a recognised industrial area, as, notwithstanding considerable investigation work into local town-planning activities, one may choose a site only to find it by-passed by a new road-development plan.

Many listeners may think that town-planning has reached a very advanced position in many districts and that it is possible to forecast, with a fair degree of accuracy, the trend of development, if one desires. This is unfortunately not the case, and very great strides are necessary in most parts of the country before planning can be said to be a success. This would appear to be a national responsibility.

Most of the factors shown in Fig. 1 are self-explanatory, and their relative importance will obviously be dictated by the product to be made. For example, under the heading "Advertisement Value" it is obvious that this is not of such importance to a manufacturer of marine boilers as to one making articles used by "the man in the street." You must therefore use your own judgment in assessing relative values, and I can do no more than show you some of the points to be considered.

Factory Design.

Having chosen your site, you commence investigations into a suitable design of factory. I would, however, emphasise that you should have a very good idea in broad terms of the size and shape of your factory before finally choosing the site, although the details may be considerably modified as you go along.

In designing a factory one of the first things to decide is just what you are going to make and do in that factory. This is obviously a question of major policy and can in general only be decided upon by the board. I should mention here what I shall refer to again later on, that is, just how far you are going in your manufacturing; in other words, what you will buy and what you will make. For example, will you, if using castings, have your own foundry? If you use wooden cabinets, will you make them up? and if so, from part-milled wood or raw timber? I agree fully that you may not know early on whether many of the items you will require will be bought outside or made inside, but we must start on some sort of foundation, however shifting it is, and someone has to make up his mind, on broad lines at least. Do not forget that we are still on the roughing cut, although a good roughing cut helps finishing later.

If in doubt on such a fundamental problem as whether a foundry is to be provided or not, make your master layout on the assumption that it *will* be required. It might be given as a rule that if the previous process work or vertical expansion is of a nature likely to attract in future, this should colour the layout, as later such an expansion could be fitted in much more easily if given consideration earlier on.

We might now consider what sort of materials we are likely to handle in our factory. Now, all factories are alike in a broad sense, that is, raw or semi-finished material comes in, is worked upon, and goes out in another form. Therefore, *material* is the factor which should have primary consideration, and Fig. 2 shows at the left a typical list of materials to be handled in a factory about to make, for instance, radio sets. Material handled may, of course, vary considerably in size in a given factory, but this can in the early stages be taken into account as an arbitrary classification of say

large, medium, small, or wood, rubber, glass, etc. You are sure to alter the original flow very considerably before you are through.

FIG. II.

	LIFTING		SHIFTING		STORAGE
	Loading and unload dock	O'head runway	O'head runway	Weighing m/c.	
Steel Bar (medium) ...					Racks with ample swinging room.
Steel Bar (small) ...	,,	,,	,,	,,	Racks with ample swinging room.
Steel Strip (medium)	,,	,,	,,	,,	Racks with ample swinging room.
Steel Strip (small) ...	,,	,,	,,	,,	Racks with ample swinging room and possibly bins for coiled strip.
Castings Ferrous ... (medium)	,,	,,	,,	,,	Bins.
Castings Ferrous (small)	,,	,,	,,	,,	Bins.
Castings Nonferrous	?	?	?	,,	Bins.
Aluminium Alloy Ingots	unload dock	O.R.	O.R.	,,	Bins or floor space. Segregate from zinc.
Alloying Materials ...	–	–	–	–	Bins.
Zinc Alloy Ingots ...	U.D.	O.R.	O.R.	W.M.	Bins or floor space. Segregate from alum.
Plastic Materials ...	,,	,,	,,	–	Floor space for barrels and kegs. Full and empty. Moderate temperature.
Wire	–	–	–	–	Bins. Warm, dry temperature advisable.
Rubber and rubber cements	–	–	–	–	Bins. Moderate temperature advisable.
Glues	–	–	–	–	Bins. Moderate temperature advisable.
Fibre Materials ...	U.D.?	O.R.?	O.R.?	W.M.	Racks with ample swing room.
Paints (high flash) ...	,,	,,	,,	–	Barrel stands or floor space. Moderate temperature.
Enamels, etc. (low flash)	,,	,,	,,	–	Barrel stands or floor space. Special building.
Wood parts					
(Part milled) ...	,,	,,	,,		Storage stands. Moderate temperature.
(Finish milled) ...	,,	,,	,,		
Small tools and misc. supplies	–	–	–	W.M.	Bins.
Machine Tools ...	U.D.	O.R.	O.R.		—
Stationery	–	–	–	–	Bins.
Customers' Repairs ...	U.D.	–	–	–	Bins.
Coal—coke	–	–	–	W.Br.	Floor space.
Complete packages for despatch	U.D.	O.R.	O.R.	W.M.	Bins and F.S.
Crates, full and empty	,,	,,	,,	,,	F.S.

Fig. 2 is important, as it indicates the special lifting, shifting, and storage facilities you might require, which on close examination may not be straightforward. For example, the storage of low

flash-point enamels, lacquers, etc., requires a special separate building situated at a certain distance (depending on local by-laws) from the main structure.

I am going to discuss in detail the various departments in the average factory, along the lines of the principles which should have consideration when these departments are being considered. Broadly speaking, the average factory can be divided into the following departments: (*a*) Receiving; (*b*) goods inwards inspections; (*c*) stores, rough; (*d*) machine or manufacturing departments; (*e*) inspection department; (*f*) assembly department; (*g*) finished stores; (*h*) despatch department; (*i*) factory service departments, such as toolroom, maintenance, etc.; (*j*) offices.

Fig. 3 details some of the points one should bear in mind in making the original layout. Most of the principles mentioned are self-explanatory, but I will comment on a few, which I have shown starred.

FIG. III.

(*a*) RECEIVING:

* (1) Reasonably adjacent to main road. Ample space outside for manipulation of incoming and outgoing goods vehicles.
Suitable height for loading and unloading goods to and from vehicles.
Lifting tackle available for heaviest goods likely to be received and despatched.

* (2) Location preferably away from frontage, to improve appearance.

(*b*) GOODS INWARDS INSPECTION:

* (3) Adjacent to receiving and despatch departments. Good lighting. One-way movement of goods; incoming material for inspection one end and inspected material out of other.

(*c*) STORES (ROUGH):

* (4) Adjacent to (*a*) and (*b*). Ground floor preferable owing to concentration of weight. One-way traffic scheme advisable.
In multi-storey buildings take full advantage of natural light from side windows for corridors between bins.

* (5) Allow suitable space for storage of batches made up for issue to shops. Consider platform over bins for light articles to increase capacity. Store heaviest and bulkiest parts adjacent to main gangways. Consider special storage requirements of certain items in relation to, for example, heat, dampness, corrosion, etc. Consider preliminary cutting or other work upon material before issue.

(*d*) MACHINE AND MANUFACTURING DEPARTMENTS:

* (6) Adjacent to rough and finished stores. Ground floor preferably. Segregate heavy and light machines. Consider whether individual drive or line shafting to be employed. Whether line production of all or certain parts to be performed or whether machines to be grouped according to type. Allow ample space for work in process, both between machines, if necessary, and for batches of work available for each section of the shop. Consider possible fashion trends of product manufactured and allow space if necessary for alterations or extensions of machine equipment required to cater for these. Consider whether space to be allowed for tool storage or repair in department.

(*e*) INSPECTION DEPARTMENT :
In case of main inspection department, locate adjacent to finished stores. Have one-way movement of material or parts. Provide reasonable space for work in process awaiting inspection. Have ample light available. Consider installation of floor inspection areas in various departments to avoid the necessity of sending parts to main inspection department between operations.

(*f*) ASSEMBLY DEPARTMENTS :

* (7) Adjacent to finished stores. Allow ample space for storage of parts awaiting assembly. Have main gangway up to above storage space and ditto away from finished assembly area (if conveyors not used). Have sub-assemblies converge on main assembly lines at correct places. Allow reasonable space for correction of rejected sub or main assemblies.

(*g*) FINISHED STORES. [*See also* (*c*) *Rough Stores*] :
Adjacent to assembly department, inspection department, rough stores, and despatch departments.

(*h*) DESPATCH DEPARTMENT. [*See also* (*a*) *Receiving Department*] :
Adjacent to finished stores.

(*i*) FACTORY SERVICE DEPARTMENTS :
Toolroom. Adjacent more particularly to machine shop, both vertically and horizontally. Consider whether tool repairs area in certain departments would be advantage over centralised toolroom.
Tool Stores. Adjacent more particularly to machine shop. Consider possible demands of other departments and whether it would be necessary or economical to establish branch stores. Locate stores adjacent to supervisor's office or desk to assist supervision. Consider whether tool sharpening and special steels, etc., required by toolroom are to be provided by tool store or toolroom, and make provision for space and machines accordingly.
Maintenance Department. Similar to toolroom. In addition, have ample lifting tackle available for moving heavy items. Consider necessity of maintenance stores for various fittings stocked.

* (8) *Power House*. Preferably ground floor or basement.

* (9) Conveniently placed for delivery of oils, coal, and other bulky supplies. Consider advisability of locating *all* power generators in this area to assist in close supervision necessary to this type of equipment.
Examples. Steam or oil engines, dynamos—alternators, compressors, pumps, transformers, main switchboard, accumulators.
Consider whether exhaust systems are likely to be objectionable to neighbours, and if so, consider special silencing or place exhausts at furthest points from possible objectors
Heating Plant. Preferably ground floor or basement [see also remarks under (8)]. Conveniently placed for delivery of fuels. Can factory heating and process heating be combined? Can clinkers and other refuse from boilers, etc., be conveinently removed? Can factory rubbish be burnt by the provision of an incinerator? If so, can rubbish be conveniently delivered to incinerator, and stored until ready for burning? Would prevailing winds carry smoke and dirt in objectionable directions?
Drawing Office. Locate in quiet area. Take advantage of fullest amount of natural light. Locate general and tool drawing office adjacent to each other as aid to co-operation. Locate tool drawing office as near as possible to toolroom, and preferably on same floor.
Production Offices. Locate as near as possible central to all production departments. Consider whether sections such as time study,

progress, etc., are to be separated geographically or combined in one area.

General Offices. Get list of various office departments. Get list of officials requiring private office accommodation and their relative locations. Get decision on whether departments are to be self-contained or in large office(s). Arrange office entrances away from factory entrances. Arrange main entrance on most impressive side. Arrange chief officials' offices looking out on to reasonable view. Don't forget waiting-room accommodation.

* (10) *Cloakrooms.* Decide policy, i.e., whether separate rooms or areas to be provided or whether clothes may be hung in shops or offices. If separate rooms to be provided decide number and proportion of each sex. Arrange cloakrooms adjacent to entrances. Have facilities on same floor and main building as workers situated.

Lavatories and Washrooms. Decide number and proportion of each sex. Locate entrances of male and female lavatories away from each other. Have facilities on same floor and main building as workers situated.

Cycle and Car Accommodation. Estimate possible number to be accommodated. Locate as near as possible to factory and office entrances. Allow ample expansion facilities. See that lighting is adequate in winter. Allow reasonable space for visitors' cars during working hours. Consider dangers to outside traffic at quitting time.

* (11) *Canteen and Kitchens.* Estimate possible numbers to be accommodated. Consider shift system of breaks, to avoid increasing canteen capacity unduly. Locate away from main buildings and in quiet location. Provide ample light. Have cheerful outlook.

Surgery. Place adjacent to machine room if possible. Have quiet location.

GENERAL.

Arrange all gangways straight with main gangways wide anough to allow two of the widest factory trucks to pass each other.

Carefully note walls, columns, buttresses, doors, drains, ducts, and other fixed equipment and fittings.

Allow suitable areas for department supervision, shop clerks, time clocks, notice boards, empty containers awaiting return to stores, shop cranes and hoists, rubbish containers, tool bins, and shop tool repair benches. Locate heavy machinery where overhead lifts can be utilised.

If in doubt allow rather more space, weight, and size than is apparently required.

Consider whether there are likely to be by-products from a department (examples are dust from polishing shop. fumes and liquids from plating shop, scrap from presses, etc.). Can these be handled with the minimum of inconvenience ?

If unpleasant working conditions are absolutely necessary to a department (examples dust, fumes, heat, excessive moisture, etc.), arrange in relation to other departments so that as little nuisance is caused to them as possible.

See that ceiling height is sufficient to allow for repair and maintenance of all plant, and that lifting facilities can be temporarily or permanently provided for such purpose.

See that provision is made for road surface around all buildings, with turning or passing areas where necessary.

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*(1) Lifting tackle heavy enough to take care of the heaviest piece of plant coming into the factory may be much too strong and

expensive from the point of view of both tackle and building frame to be really necessary. It is felt that one might cater for the maximum weight and size of the usual run of equipment and if a really heavy occasional item arrived, shore up the beams and borrow special slings. This is somewhat important as a general principle because if all designers of buildings, equipment, etc., designed for the extreme in everything we should have some very peculiar and expensive results.

This is particularly noted in the case of heating installations, where occasionally extremes of weather give one, through physical discomfort, the idea that the plant is ineffective, forgetting the rarity of such occasions.

There is of course the opposing viewpoint, this being that a little larger size plant, etc., cost usually very little more than the smaller, and why not play safe with the larger ? Unfortunately this again would lead to embarrassment if carried out on everything, and I can only suggest that you consider trends of design as much as possible in your deliberations, so that allowances can be made where allowances will possibly be required later on. I would, as a guide, however, state that I have seen more trouble on account of choosing too small a unit or space than too large. A typical example comes to mind, this being an incinerator which, on conditions existing a short time ago, would have been ample in size if installed to a certain capacity. We took a chance and ordered it twice as large, and to-day, owing to additional activities of the Company, this plant has to be run day and night.

*(2) However clean and tidy your factory staff is, you will alway get rubbish of some sort for disposal, and you might as well face up to this sooner than later. Empty cases, crates, barrels, etc., for return and disposal never can look very tidy, and it is advisable to allocate a space in the early part of the layout for such items. This should if possible be adjacent to the Goods Inwards and Outwards department and be hidden from the main view.

*(3) One practical difficulty often found in inspection departments is priority of inspection, and a one-way system would be a great help in such circumstance.

*(5) This depends on your method of issue to shops, but usually stores make up such issues at leisure into trucks and containers, and space should be allocated accordingly.

Rubber items, for example, deteriorate rapidly under certain conditions ; wire, particularly silk-covered, if used for electrical work, should be carefully stored, and when one deals with many chemical compounds the problem is also acute. Great care should be given to storage conditions in your layout.

*(6) Most of you will no doubt think and say that you long ago gave up trying to follow the thoughts and efforts emanating from

the design office. However, whether our private reactions agree with the above or not, the fact remains that design policies play a very important part in the life of the production engineer, and he is surely entitled to be kept well-informed on such trends. Before completing your layout you should endeavour to probe the minds of the designers to the fullest possible extent, so that, as far as possible, allowances should be made for the changes required later on.

If you examine your own existing layouts in relation to what they were even a few years ago, you will possibly be surprised at the considerable changes you have made on account of altered requirements ; changes which have occasionally been very awkward to make on account of more or less permanent restrictions bordering the departments being altered.

I cannot give you much advice on your own design trend, but you can all see notable examples on every hand, such as the growth of die-castings in relation to press work ; the colossal increase in the use of plastics to the detriment of other activities such as metal-plating and polishing.

This is not the time or place to discuss new model policies, but I would like, at this juncture, to mention that in my opinion this alleged desire on the part of the public for change is a much over-rated one, and is an extremely inefficient one from all points of view. From our particular viewpoint as production engineers it forces upon us the need for flexibility of mind and layout, and to many of us the " philosopher's stone " of the future is a rubber factory. Indeed, I think the most important work in the vocabulary of the planner to-day is the word " flexibility."

*(7) I have always found that we are rarely pessimistic enough to imagine any bad workmanship in our own factory, and the results are sometimes awkward. Remember that perfection is not possible, and allow *somewhere* for those rejected or faulty parts and assemblies to be put right without affecting the main flow.

*(8) It is useful to remember that a basement may be of great assistance in locating the power-house and/or heating plant, thus saving valuable ground floor areas. Fig. 4 shows how a heating installation was placed underground, a portion of the stores loading-bank being used to give natural light.

*(9) This undoubtedly is important, as such equipment, being of a key nature, usually merits special attention, which is not so effective if the equipment is scattered.

*(10) One interesting method of storing clothes in a factory was that of using a long wall with hooks thereon. After a certain time a false panel was lowered down, thus covering all clothes and preserving a neat appearance.

*(11) This is particularly desirable, as canteens are often used for

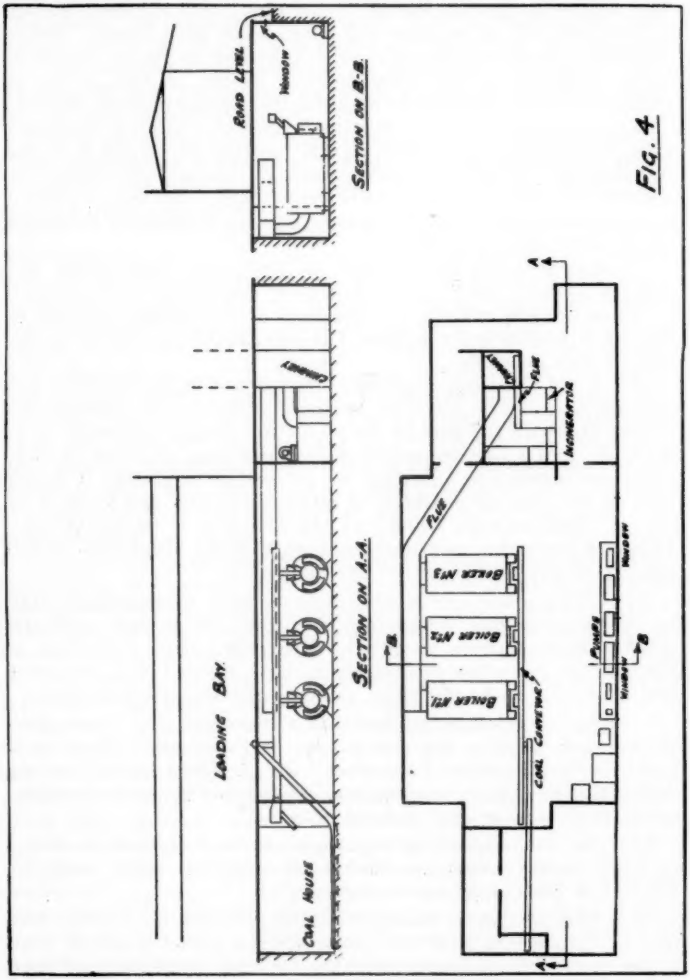
ROAD LEVEL
WINDOW
SECTION ON B-B.
LOADING BAY.
COAL HOUSE
SECTION ON A-A.
BOILER No 3
BOILER No 2
BOILER No 1
COAL CONVEYOR
FLUE
INCINERATOR
POWER
WINDOW
A
B

FIG. 4

evening functions, and it becomes difficult to control visitors when they have to enter the main factory building to get to the canteen.

General Principles Governing Location of Departments.

Having gone through all the points raised in Fig. 3 and as many others that occur to you which have not to me, you will be in a fair position to locate your departments relative to each other, after first having prepared a flow-sheet showing the main flow of materials in your factory. The good old method of using pieces of cardboard and juggling them around each other on a flat board on which the site is drawn is excellent in the first stages, and saves much time.

It is really amazing how many combinations you can make, and sooner or later one is evolved which, subject to your now heavy breathing not blowing it about, can be traced off. I have seen numerous examples of apparently hopeless layouts being considered where quarts have, on the surface, to go into pint pots, but which after various attempts have come out in a satisfactory manner.

One reasonable way in which to decide the relative efficiency of various layouts is to take a representative list of the more important components and assemblies to be worked upon and measure off with dividers and rule the distance travelled by them through various departments, including stores, until they leave the factory. Don't, when you use the dividers, forget that there may be walls between departments, but go through the doors like other people will have to. Another good method is to use coloured strings and special drawing pins to indicate the flow of material and parts.

I have already mentioned flexibility, but it will not do any harm to do so again. While on this subject I would like to quote, with acknowledgements, an extract from a paper entitled " Revamping Equipment and Layout " by Ralph F. Cohn, in the American Management Association Production Series. This is it :—

> Unexpected changes in methods of processing have a way of making new equipment look like a herd of white elephants. Such process changes are apt to affect layouts to a greater extent than equipment, since equipment can often be used elsewhere, unless of a very special nature. To help minimise the losses due to changes in process, I keep in mind a second rule : Buy the most portable unit available and so make it easy to change the layout whenever necessary.
>
> Flexibility in equipment is exceedingly important where style and quality require frequent changes in processing.
>
> One of the primary purposes of a good layout, of course, is the reduction of handling charges. Regardless of the product that you or I may be producing for sale, regardless of whether we are in a steel mill, a textile mill of the live stock yards, we are all in

the handling business. The chances are pretty good that our handling business would make a poor showing if a set of accounts were available to show just how much money was being spent each year moving goods in process about the plant. If you think I'm wrong, try this: Take the whole of a sizable portion of your plant and list the daily wages of the truckers, elevator operators, crane operators and others primarily devoting their time to handling. When you think you've finished, you've just gotten a good start. Pick out any ten names at random on the payroll. Spend one hour with each and keep track of how many minutes of each hour each so-called operator is actually moving goods in process, supply materials or equipment. Such a "sample" should be enough to convince you that you are paying skilled operators a dollar an hour for portions of their time that is either wasted through unnecessary handling or could just as well be done by a forty-cent man.

There is another rule that I use. It opposes the "bigger and better" attitude. My thought is: Buy two little ones in place of one big one. Why, that's uneconomical, you'll say! Yes, it would be if carried too far, but the usual mistake is in the direction of bigness. It's nice to say that your plant has the largest machine in the world for putting leopard spots on cowhide and that the operating cost is only three dollars per thousand spots. Fine—so long as people read Tarzan and demand leopard spots. But how about when the demand equals only half the output of the machine and then settles down to one quarter of the output? You'll wish you had the smallest machine in the world. Or you'll wish you'd bought two or three small ones and could move the idle machines out of the way. Furthermore, if the large machine has to be shut down for repairs, production of the product ceases, while with two or more smaller units, repairs can usually be accomplished during periods where full capacity of all units is not required.

One more thought on layouts. Given: A layout problem involving a main production line with a portion of the line requiring expansion due to long time required for that particular operation. Or assume that the specifications on a steel part have been changed requiring some units to be electroplated and others to be enamelled. There isn't room for the electro-plating equipment in parallel with the baking equipment. The floor space has already become over-crowded leaving no room for plating tanks. The sales department insists that either finish be applied whenever specified on the order. It's a mean problem but perhaps a little trick I learned years ago will help to solve it. The trick consisted of making four equilateral triangles out of six whole matches. Difficult until someone suggests that the triangle

need not all be side by side on the same plane. Get up into the third dimension, build a pyramid out of the six matches and

FIG. V.

FLEXIBILITY AND EXPANSION PROBLEMS IN RELATION TO:

ELECTRICITY ...	Supply Company's maximum delivery to premises. Location of Supply Company's transformer and switch station, and our power station. Cable capacity in relation to possible demands of departments. Distribution of cables from Supply Company and own power station. Transformer and switch area to deal with power demand increases. Location and number of distribution boards in departments to cater for power demands. Isolation of departments in case of repairs (ring mains). Emergency or pilot lighting. Metering individual departments.
WATER	Supply Company's main delivery to premises. Possibility of different supplies being required for drinking and process work. Fire water-mains. Pressure in multi-storey buildings. Cooling water provision where necessary. Location of Supply Company's mains and meters in relation to demands. Ease of extension of pipes.
GAS	Supply Company's maximum delivery to premises. Location of Supply Company's mains and meters in relation to demands. Pressure variations in relation to distribution pipe sizes. Metering individual departments (including meter space).
COMPRESSED AIR	Space for adding compressors if required. Mains large enough to take increased quantity.
PROCESS HEATING	Possible increase in boilers. Possible increase in bunker space. Possible increase in ash, etc., disposal facilities. Distribution of additional demands to sections thought liable to increase requirements.
DRAINS	Do not sink internal discharge pipes into floor unless absolutely necessary. If pipes are redundant do not disconnect and leave, but remove altogether. Have plenty of drains outside the building.

there are your four triangles, three sides and the bottom. A nice, compact layout where four triangles take the same floor

space as one. I've always remembered that little match trick as a reminder that a room is not just floor A room has three dimensions and, if necessary, the floor above can add three more. In this case, the plating department was housed above the enamelling section, maintaining a straight flow of materials regardless of finish, but not all on the same level. So, in making a "floor plan" don't forget the walls, the ceiling, and, if available, the floor above. When the restrictions of the building itself place limitations on layouts, the building should be regarded as part of the equipment and appraised as to its efficiency as a tool for manufacturing purposes. We are apt to regard buildings as more permanent and less a part of manufacturing expense than the machines they enclose.

I was particularly struck with the arguments against the " bigger and better " attitude, as it is certainly contrary to any American attitude I have so far heard.

Flexibility and expansion may be allowed for in numerous ways and should be particularly studied in relation to power requirements. It is not usually difficult to move assembly benches or offices about, but it is difficult with machines and equipment using gas, air, electricity, drains, etc., and these services should be laid out—not necessarily in relation to your present requirements—but to possible future needs. Some of these considerations are detailed more fully on Fig. 5.

One other angle on this question: In laying out departments and allowing for expansion, length, breadth, and height should be taken into account. Taking Fig. 6 as as example, in length you could allow for expansion towards arrow " A " and in breadth towards arrow " B " these movements perhaps corresponding to the integration of the company's business and the additional demands due to expansion of trade.

In this example it may be assumed that at a later date the die castings now bought out are going to be cast inside. This, being an earlier operation than machining, should be allowed for in that relationship and area " C " could be reserved or temporarily allocated to activities requiring little efforts to move later on. The gangway, area " D," would be developed first of all, and lengthwise expansion of area " C " would take place towards " A." Similarly, area " E " and " F " would provide expansion in future for both existing processes (towards "A") and possible new finishing processes towards " B."

I cannot hope fully to cover this matter in the short space of time available to me, but there is just one other important point in connection with planning departments that I would like to emphasise that being the subject of supervision.

With all the incentive plans in operation nowadays, I still feel

that supervision of a high order is necessary to get the best out of any department, possibly even more so now that staff functions of various kinds are so much in evidence.

Now, control cannot effectively take place at a distance, and to make it effective, the supervisor should have a self-contained area in which to exercise his functions. He should also, if possible, have a flexible department or departments to cater for the emergencies that are always happening in a major or minor sense in the average factory.

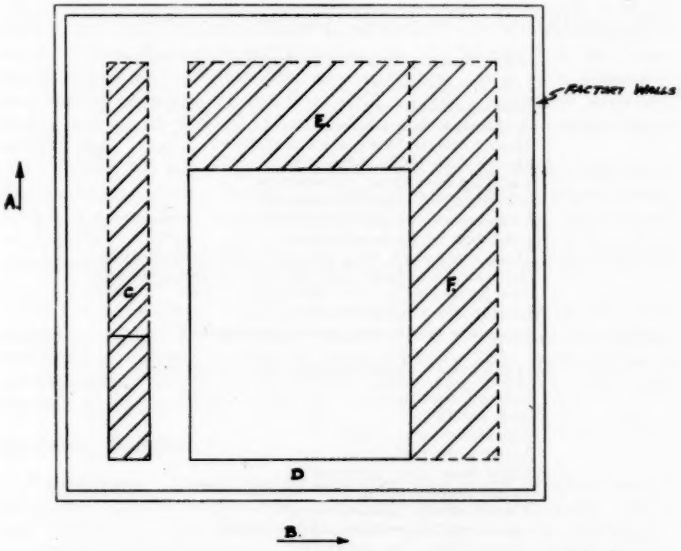

FIG. 6.

Let me give you an example. You have receiving, stores and despatch departments, the duties of each being locked together to a very large extent, which can be seen any day by asking the purchasing department if a consignment of shortage parts is in. They say "yes," but they are often far from in if they have just arrived. Indeed, the average progress department seems to experience just as much trouble getting parts through receiving, inspection, and into stores as later on, and it is not so easy, if rejected, getting them out of the factory.

Under such circumstances, one departmental superintendent over these allied departments will possess a considerable advantage,

another being the flexibility previously mentioned, where, if a rush in any section arises, labour could be drafted across from another by the superintendent in a manner which could not so easily be accomplished if each section was water-tight.

Bearing all these points in mind it would appear that geographically the stores, receiving, and despatch departments should be together without other departments cutting them in sections.

FIG. VII.

FACTORS INFLUENCING SINGLE AND MULTI-STOREY BUILDINGS

SINGLE-STOREY CONSTRUCTION INDICATED WHEN :—

Ground cost cheap.
Site reasonably flat.
Expansion area ample.
Heavy and/or bulky work performed.
Heavy floor loads indicated.
Lighting necessities considerable.
Flexibility of layout considerable.
Low cost of construction necessary.
Vibration of work performed.
Hazardous work, such as explosives, worked upon.
Separated buildings indicated for various processes.
Fire hazard high.
Considerable head-room required.
Long line production processes indicated.

MULTI-STOREY CONSTRUCTION INDICATED WHEN :—

Ground cost heavy.
Site not flat.
Expansion area small.
Light work performed.
Light floor loads indicated.
Economy in heating costs necessary.
Electricity for lighting cheap.
Gravity-fed operation can be utilised.
Advertising value necessary.
Little receation space possible (roof garden can be provided).
Ease of expansion required (upwards).
Initial cost of construction not so important.
Drainage simplification required.

This is particularly important in multi-storey buildings where it might be necessary for the supervisor to go up and down stairs in order to control hs responsibilities. Control over lavatories and cloakrooms in his areas could be cited as one difficulty, another irritating one being the difficulty of getting into touch where necessary, by management. All things being considered, I think this question of supervision, while seemingly being more an organisation problem is bound up intimately with departmental planning.

Factory Types.

I am going to discuss here, only in a brief manner, the general types of factory buildings. There are roughly three types: (1) Single-storey buildings; (2) multi-storey buildings; (3) combination of above.

A controversial question continually arising is this matter of single *v.* multi-storey buildings. Let us examine the relative merits of the two types, which are briefly summarised in Fig. 7.

Summing up, for small types of products, the multi-storey building appears to possess reasonable advantages, and even with a fairly heavy and bulky product there is no reason why a combination of single and multi-storey buildings should not be worth while. One might visualise, for example, one assembly—such as a chassis—progressing on a line on one floor with a mating assembly, such as a body, moving in parallel above and dropping down at certain spots to link up.

It should be borne in mind that each of the advantages and disadvantages shown should be carefully considered in consultation with the specialists, but certain of the factors have to be assessed on experience rather than L.S.D., and my own experience is that disadvantages such as increased transportation cost and fire hazard, for example, are more apparent than real.

On the question of initial cost, which is always one of the most important, rough figures would indicate that the cost of an average multi-storey factory would be approximately 25% higher than a corresponding single-storey, north light construction, and that heating costs would be about 25% lower.

Building Details.

Foundations.—Little can be said from our point of view except that they should be generous, carefully laid, and drained. Your site will have a considerable effect on this angle of the building.

Drains.—These should be adequate at exit to main sewer to cope with extensions. A liberal provision of surface and soil drains should be made all around factory. Consider necessity of cement-lined sumps if acid is dealt with. See that complete diagrams of all drains exist.

Entrances and Exits.—Entrances should be at ground level if possible, in order to assist traffic.

Doors should be hung on generous hinges and an automatic closer fitted to avoid draughts. Kicking strips in stainless steel $^1/_{16}$in. thick and bakelite finger strips have proved satisfactory. Large access doors, metal reinforced, should be provided for the handling of large and heavy machinery. Doors of 10 ft. high and over should be metal-frame wood filled, otherwise much trouble will be ex-

perienced with a wood door swelling in wet weather. Emergency exits should be numerous rather than scarce. Double swing doors should have panel with reinforced glass in order to avoid injury to people using the entrance. See that altered floor levels do not come at less than 5 ft. from doors.

Traffic Routes.—See that these are ample—8 ft. for main aisles, 6 ft. for others is a fair figure to take. See that they are cleanly laid and marked out, with sharp corners avoided, or if unavoidable that no blind corners exist.

Work to one-way system as far as possible.

Floors.—There are many types of flooring, and a brief summary of these are to be found in Fig. 8.

Roofs.—Some points to be considered here are: (*a*) Heat losses, which vary considerably with different roof materials used; (*b*) insulation, which is tied up with (*a*) and prevents condensation and consequent deterioration of building and contents; (*c*) possibility of gases, fumes, and heat being present in building; (*d*) amount of natural light required.

Walls.—Concrete permanent outside walls are probably the best all-round construction. Some points for consideration are: (*a*) Heat losses (brick shows up better); (*b*) damping out noise (here again brick is probably better); (*c*) vibration; (*d*) waterproofing, especially at sills and lintels; (*e*) ease of painting inside surface; (*f*) ease of attaching fittings to surface.

Windows.—Points for consideration are: (*a*) Cleaning. This may be difficult in multi-storey buildings if special provision is not made for hanging cradles or cleaning from within; (*b*) leaky glazing troubles (putty can vary very considerably, and should be closely watched); (*c*) sloping lintels and window-ledges are highly desirable, to avoid an accumulation of dust and miscellaneous items, which so detract from the appearance of a shop.

Elevators.—These should be just large enough to cope with all normal traffic, but not larger. Points for consideration are: (*a*) They should be self-levelling; (*b*) they should have fireproof doors; (*c*) if busy, one operator with controls in cage; (*d*) hardwood floor; (*e*) very large sheaves to minimise rope wear; (*f*) adequately rated motor; (*g*) cage gates protected from trucks entering or leaving; (*h*) lift shaft to be vented; (*i*) spring oil buffers undercage and weights.

Consideration might be given to one or more lifts going up with loads, and alternate one(s) going down. It is suggested that lifts should be fast-moving, as although little time is spent between one floor and another, the toning-up effect of a speedy lift is considerable. I would also suggest that escalators be given consideration in multi-storey buildings, in view of their successful application elsewhere.

To avoid the use of elevators for rubbish disposal in multi-storey

buildings, a suitable chute with openings on each floor (leading perhaps direct to the incinerator room) will be found extremely valuable.

FIG. VIII.

FLOORS FOR INDUSTRIAL BUILDINGS

DESCRIPTION.	REMARKS.
Stone concrete, 6 in., reinforced. Mix 1 : 2 : 4 on ground.	Good for storage areas and ordinary wear. Dusty surface.
¾ *in. or* 1 *in. granolithic,* grit top special finish on hardcore or cinder concrete base.	Very durable; hard; smooth. Reasonably dust-free. Treated metal filings add to surface life. Should be on solid base. Good for many types of heavy manufacture and use. Cracks should be filled up with asphalt to prevent chipping.
Asphalt compositions. Poured about 1 in. to 1½ in. thick on concrete, brick, or solid wood base. Concrete base should be in aluminous cement, as this resists corrosion better than portland.	Usually for protection from acids, etc., and waterproofing of areas. Quiet and clean. Not good for heavy trucking operations or where soaps are used. Surface tough, but not so hard as concrete.
Protection of concrete by treatment or painting (about three coats).	Various media to suit specific needs. If structure of floor is cracked, they will not make it waterproof. Keep down dust (may add to wearing quality of surface). Usually require two to four thin coats for good penetration. Paints require frequent renewal, but add to appearance. Concrete top can be mixed with ochres or other pigments for permanent colour.
Tiles; Linoleums.	Usually for offices. Are stuck to floor or set in mastic on concrete, brick, or wood. Appearance very good. Too frail for heavy manufacture. Usually quiet and clean.
Soft woods 1¾ *in. thick.*	Long leaf yellow pine, spruce, etc., can be placed directly on floor beams. Not good wearing surface for trucking, but satisfactory for storage and like areas. Quiet, clean, and healthful.
Hard Woods ⅞ *in. thick.*	Oak or maple. Good to surface over old wood floors in offices and light manufacturing areas. Set in mastic on concrete. Must be kept dry.

Hard Woods 1¼ *in. thick.*	Oak and maple. Can be set directly on beams. Must be kept dry. Good for light and moderately heavy manufacture. Will not stand heavy trucking. Clean, dry, fairly quiet.
Wood Blocks 1 *in. to* 2 *in. Vertical grain.*	Best wearing of wooden floors under trucking. Should be kept dry even if treated. Quiet, clean, healthful. Can be set on concrete, brick, or wood base.
Steel Plates $^3/_{16}$ *in. to* ¼ *in. on wood floors.*	Can be installed while plant is operating. Very long life if properly fastened. Slippery under oil, water, dry dust.
Cast Iron Tiles.	Can be set on concrete or mastic. Very durable. Non-slip. Noisy.
Hard-burned Brick on edge.	Very noisy with treads. Good in aisles and at points of heavy traffic. Requires structural base. Little dust from wear.

Partitions. These are important, and can also be very costly. The home-made type is not a thing of beauty, and cannot usually be taken down and re-erected—a very important feature in our flexible layout. On the other hand the better-looking unit construction and more flexible types are certainly expensive. I do feel that partitions should be made in steel, and a little more money could be invested in the average factory than is done. From the fire-proof point of view alone, this is extremely desirable. Ample protection from trucks should be specified, this being best provided by a curb about 10 in. high. See that blind corners are eliminated as far as possible, and that ample thickness glass is provided in places where people tend to lean against the glass.

Ceilings. These should be smooth and easy to wash down, and naturally as much reflective value should be gained as possible. Consider necessity of having to attach fitments to underside.

Stairs. The following points should be considered: (*a*) They should have non-chip and non-slip nosings; (*b*) they should be well-lighted, to avoid accidents; (*c*) handrails should be provided each side; (*d*) frequent landings are desirable, to stop falls; (*e*) It is desirable that they should be painted with a light-reflecting paint above a dado; (*f*) windows should be above reach; (*g*) corners should be rounded, for ease of cleaning.

This, I think, is an opportune time to quote an extract from "Safety Bulletin No. 45, for November, 1936, page 84":—

"The classical example concerns a girl who fell downstairs. A committee had the fact reported to it and promptly went to look at the stairs. It found them sound and in good order and said it could find no cause for the accident. An experienced investigator

subsequently carried out an inquiry and found something as follows :—

(1) The girl was hurrying and had tried to run downstairs.

(2) The accident had happened after dark. The committee had looked at the stairway in the daylight and had consequently not noted that the artificial lighting was badly arranged.

(3) The stairs had just been washed and were slippery.

(4) The girl's shoes were in bad condition.

In this case there was no detectable exciting cause but there were several contributory causes which could all be acted against.

Incidentally, on the question of tracing the cause back as far as possible it may be noted that causes 1 and 3 were further investigated to find out whether the need for hurry was something that could be eliminated by reorganisation of any kind, and whether the stair washing could be done at a safer time."

Ducts. The value of underground and vertical ducts is considerable, giving as they do facilities for carrying service pipes of all descriptions from place to place and from floor to floor without disturbing surfaces. They should of course be reasonably ventilated and could have brackets for supporting cables and pipes let in during the construction.

Heating and Ventilating System. I am not going to say much about the various systems at present in use. I will say however that more recent pressure hot-water systems appear from experience to possess many advantages if the rather higher initial cost can be borne.

The continued growth of air-conditioning plants is I think a step in the right direction, and I believe that in a few years no building whether used for offices or industrial purposes, will be complete without some better form of control over ventilation problems than can be obtained by the very rough-and-ready one of opening and shutting windows.

Lighting. It is usually too much to assume that the detail layout of each department is completed before the wiring is installed, so that lights can be dropped at the most convenient places. This would be a great advantage, as practically all conduits could be hidden.

Lighting should be generous as fittings do tend to decrease considerably in efficiency after a time. Ample facilities should be made in conduits and ducts and distribution boxes for extensions to lighting, and it is advisable to call in a lighting specialist for a large job, as the improved types now becoming available are well worth investigating. See that lighting facilities are not only arranged in departments but in all the odd places such as stairs, sheds, corridors etc.

Fire Protection. This will depend a lot on the requirements of the local authority, and is more a responsibility, from the exit

point of view, of the architect. Remember however that an emergency exit will also be used at other times, and should therefore be in a reasonable position in relation to traffic and other interferences. In connection with the fire hydrant positions, see that they are located where there is little likelihood of damage from passing truck, etc., and that work cannot be stored as as to interfere with free access.

Factory Extensions.

You will have realised that many of the foregoing remarks also apply to extensions to an existing factory. You remember the advice to those about to get married—DON'T ! Well, that is how I feel in relation to extensions. I think very deep consideration should be given to the present layout before it is decided to go ahead with extensions, as I have seen so many examples of layouts which could be modified within the existing walls without recourse to the chaos of extensions.

I have been in factories where extensions have been in progress and seen half the factory idle, due perhaps to design changes or seasonal trends, and have been struck by the paradoxical nature of it all. It may be a little outside my scope, but I do feel that at times extensions are undertaken in too haphazard a manner. Let us assume, however, that due consideration has been given, and a decision made to go ahead. Well, I think the very first thing to do is to very, very carefully set down a schedule of progress, and by hook or by crook attempt to work to it. Building an extension reminds me of a jig-saw puzzle, and it is very important to know in which order you will deal with the pieces. The British weather is not a great help in such planning, and is likely to put it out unless you choose your period well. It is highly desirable that these moves be planned out on the board before starting off the extension, and it is as well to bear in mind that unless you are lucky, production will still be expected while you are moving. I cannot over-emphasise the importance of planning these moves early on, as I have seen so many occasions where the value of this is borne out.

Planning the actual building is important, and a good scheme is to have a weekly meeting of architect, main contractor, clerk of works, sub-contractors, and your own representative, on the site, so that progress (if any) can be reviewed and promises given. Minutes should be circulated promptly, to all parties, with allocation of duties clearly stated.

One question which has always come to the front in my experience has been the one of temporary occupation or installations. You are apt, through anxiety, to get in ; to authorise temporary means of doing so. But I warn you that you may be making a rod for your own back. Many a temporary fitting has caused considerable

trouble in all directions because time cannot afterwards be spared to make a permanent job, as time later on is always more valuable than when you are "mucked up anyhow." Even, therefore, at the risk of slight delay on such questions as allowing time for stairs and floor surfaces to harden off, paint to dry, permanent wiring to be put in, and a host of other things, *do* consider the advantages of having a job which all the odds and ends can leave alone afterwards, to the advantage of your temper and output, and the appearance of the job.

It is important to realise that extensions to manufacturing departments may imply extensions to service departments and other facilities such as cloakrooms, lavatories, cycle accommodation, and so on, this being a point which is frequently overlooked.

I stated a little earlier that extensions should be carefully considered before undertaken, and it is surprising what economies in space, and consequent increased manufacturing facilities, can be made by even such questions as substitution of steel furniture, bins, partitions, etc., for the existing, and the use of overhead storage facilities. These and many others will occur to you, which should be considered, and even if the extension is put in hand I would suggest that it should provide an occasion for a review of your present arrangements, so that the latest ideas can be embodied in the extension, and the rest of the factory brought into line in many directions.

Discussion.

THE CHAIRMAN (Mr. R. Broomhead): We have listened to a lecture this evening rather out of the ordinary to those we are accustomed to. Mr. Puckey has told us nothing about production machines of any description. He has however told us something about factory planning, and I think you will all agree that if we gave Mr. Puckey the job to plan a factory, and if he planned it on the lines stated in his paper, it would appear to be ideal.

I do not know whether we have any factory planners here to-night, but some of the points the lecturer has raised must sooner or later come before our minds when we have to allow for extensions in our various works. There was certainly one point that struck me rather forcibly, and that was the very first consideration was not even the cost of the new factory. The next point I observed was that he had even allowed for taking away the rubbish, which of necessity always gathers. There was another point which was not quite clear to me, and that was the hanging up of clothes in the factory or workshop. I think the lecturer spoke of lowering down some kind of cover for them, which means shutting them up probably in a damp air, which I do not think would be received very favourably by the people who would have to wear them. Also, when you were considering your plating shop, you found you had no room in the plating shop for the rectifiers and you proceeded to put these in the shop above. Does not that mean that you have got to get some man to control them in addition to the man who does your plating?

Mr. PUCKEY: I think you were trying to emphasise the cost of a factory as being an extremely important one, but I would like to say this of factory building; a factory is not a thing that is going to last only one year or even ten years, and I contend that if you are going to get a good job, a little extra money spent on the factory is well worth while. I have seen so many examples of corrugated iron affairs, which look very nice at the beginning when everything is all new, but you forget the maintenance costs afterwards. If you are going to build a factory you should have that little bit of extra money put into it to make it more permanent and to decrease maintenance costs as you go along. Maintenance costs can be very high indeed; it has been one of my big problems. As regards the hanging up of clothes, I mentioned one method where clothes were hung up, but I am distinctly in favour of separate cloakrooms away from the main floors, as I do not like to see the whole

manufacturing area a semi-cloak room, with clothes sometimes hanging on the wall and sometimes in other places, I do think separate cloak rooms are highly desirable. A scheme I saw once struck me as a very simple one. You have a main corridor, and there are hooks along this corridor. When people came in they hung their coats on these hooks, and a panel came right down in front and rested on the ground, allowing a breathing space between the false panel and the fixed panel. People coming along thought the false panel was the side of the corridor, but it was a false partition, and from the point of view of wet clothes it was ideal because you had a circulation of air. As regards the plating shop and rectifiers, that point was not important from a maintenance point of view, because a rectifier needs very little in the way of maintenance, and it was considered they would be better placed up above. In this particular instance they were put in a corner of the tool stores, which happened to be up above, and adjacent to the tool stores was the maintenance department, and when any maintenance was required it was better and more convenient than if they had been placed in the plating shop.

MR. BEDFORD : I think the lecturer was rather more in favour of the multi-storey building than the single storey. From the point of view of transport, convenience of handling, etc., I thought the ideal thing was a single storey building. There seems to be a lot of limitations on the multi-storey building, one of the main ones being lighting, You get the multi-storey building with very little natural light in the middle particularly. The modern building has got a tremendous area of glass, but even that does not give you light in the centre of the building, and you have to keep artificial light going. Another point, the lecturer referred to ducts in his building, and under ground. Now, personally I cannot stand underground ducts, they are always in the way if you want to put a machine down, they always break down if you run a truck over them and if you cover them in with steel plates the plates bend, if you pass a machine over the top when you want to shift something. I think all cables, pipes, and any service mains and the like put in should be hung up. We had to carry out an extension and put up a reinforced concrete building, and I would emphasise the importance of planning in putting up a building of that type, such as if you have got a hung shaft, if you have got all water, gas, electricity details stored away so that these can from time to time be got at. You do not want to start plugging concrete walls and hanging stuff on concrete beams. For a main shaft drive we had to consider hanging a shaft on concrete beams. The building was a long one and we had to allow for expansion to the building, as a building of 350 ft. expands about $\frac{3}{4}$ in. in certain temperature. We had tubes at inter-

vals right across the beams and then put some angles to carry out hangers, and also slide plates to allow for expansion. We also put tubes into the concrete beams so that if it was necessary we could put up countershafts, etc. It had been an ideal system of planning for a ferro-concrete reinforced building and very much better than any steel work.

MR. PUCKEY : I do not want you to run away with the idea that I am entirely in favour of the multi-storey building. For quite a lot of work the single storey building has advantages. With multi-storey buildings one has certain restrictions in width, etc. I do feel however that a multi-storey building has a lot in its favour, although not in initial cost. I think I mentioned that the average multi-storey building would cost about 25% more than a corresponding single storey building and that has to be borne in mind, but you must consider the uses where a multi-storey building is concerned. There are of course many cases where you have no option but to build a multi-storey building, and it is surprising how many people are going over to multi-storey construction where originally they would not consider anything but single storey construction. The fact does remain that there is a very definite trend towards that type of construction. I am sorry Mr. Bedford condemned ducts as he did, because my experience is certainly not on the lines he has mentioned, When one considers heavy machinery, no doubt ducts are rather a nuisance because you have to consider where your ducts are in relation to the foundations, and also when moving heavy machinery, but if one has only reasonably light machinery, one does not seek very much in the way of foundations and it is surprising the large number of machines that are merely put on the floor. I suppose in the average factory a very large proportion of the machine do not require foundations at all. You must of course have reasonable covering for your ducts, and I consider ducts are extremely valuable for carrying services around and they economise floor space. I emphasised their extreme value in conveying services through London ; just consider if they did away with ducts carrying the various services around. I certainly think ducts could be more used than they have been in the past. Knowing where your duct is, it is a very easy matter to dodge it. I think the question of putting tubes into concrete is a very good idea indeed, if they are numerous and large enough to aid flexibility.

MR. RAGGETT : By having a single location in the factory for the receiving department and despatch department it would seem that the material going out would get in the way of the material coming in. It would seem a better arrangement if the despatch department was in another position.

MR. PUCKEY: We might almost suppose that on a round-about in road construction, vehicles come charging in from four sides, but they do not hit each other. If in factory planning you set certain principles, and having got those principles in mind you say, just how far can I go towards maintaining them? Probably you have to sink some of them, but unless you attempt to embody these principles in your layout you are not going to get very far. You start off with a theoretical assumption and then try and work your layout round that ideal. I consider the question of supervision of extreme importance and this should be borne in mind when laying out departments, and if you keep your principles in mind you may achieve something which while not being perfect will go a long way towards satisfaction.

MR. SOLLOWAY: I think the lecturer has given us a very comprehensive survey on factory planning. Two things I noticed particularly, which I had hoped he would have mentioned a little more fully, and I would just like to ask his opinion. Firstly, fire fighting equipment. I think that is a very important thing in laying out a factory. Although he mentioned it slightly, I should like to ask his opinion on the drenching and sprinkler system, as I understand the sprinkler system would be a big safeguard and also instrumental in bringing down your insurance costs. Secondly, as regards lighting, I have in mind the multi-storey building and daylight. You would require overhead light, which would necessarily mean that you would have to use the most suitable artificial light available, and on that point I would like to ask if he could give us his experience on the mercury vapour light, and also the non-shading type of light.

MR. PUCKEY: The sprinkler system is a very useful system. I personally do not think in relation to its cost that it has a very great deal over the ordinary hydrant, unless you install it in a department which works practically automatically and without supervision. There are of course departments which are liable to fire and which may for a considerable period have no one adjacent to them where, perhaps, automatic production is being carried on. I consider the sprinkler system in cases like that is probably well justified, but in the average factory where there are people available the whole time in the department and where you have a reasonably well organised system of control by a foreman or a watchman or some other people, and in the case of a watchman ensure that the clocking stations are suitably located and that the ground has to be covered at frequent intervals, then the ordinary hydrant and hose is perfectly satisfactory. The fire brigade should of course be kept up to scratch with frequent drill. Regarding lighting, I

have had some experience in mercury vapour lighting. We have installed this type of lighting; it has been in for some years and has been reasonably satisfactory. One thing against these lamps is that they decrease in output very considerably with use. Their efficiency drops and you perhaps do not notice it unless you make a tour with a meter of the various departments and register the actual intensity of light that you get, and you find people are straining their eyes. It is a very efficient type of light but gives rather a peculiar effect, particularly if one has a blotchy countenance, and girls do not like this lighting particularly on that account. One thing you have to bear in mind; there are certain materials to which mercury vapour light gives a false colour.

MR. BOWKER: It struck me that the lecturer did not mention what I consider is a most important thing about initiating a works. Supposing I was to start, say, a hat factory about 15 miles from here, somewhere in the wilds, my rates and taxes would be very low, and I could have a single storey building, but could I get the labour? Most decidedly not. You could not get people transported there and back to where they want to live because they were bred and born there. If you started to find accommodation out in those wilds your rates and taxes would go up and you might as well have your factory in Luton. I have come across two or three cases in the engineering line where men could not be got. There was a place near Loughborough, land was cheap, rates and taxes were cheap, but when the men had finished work at six o'clock, and had had their tea, if they wanted to go to Leicester or Nottingham for amusement, by the time they got there it was time to go home, so the only people who could get there were people who could not get a job in a big town where there was industry, and that struck me as a really important consideration when you are thinking of starting a factory anywhere.

MR. PUCKEY: I must apologise for not mentioning this point more specifically, but I think you will agree in the limited time it is difficult to cover adequately everything. The one idea I had in issuing the diagrams was to bring forward certain things which perhaps I could not discuss fully, but which could be jotted down as points for later consideration, and I think if you will turn to Fig. 1 you will find that the labour question comes fairly near the top, and I must say that I think that really covers my excuse for not saying much about it. Under item (*d*) of Fig. 1 we get "LABOUR —type, proximity—transport—trade cycle in relation to other local industries." You get occasions where firms making, say,

radio sets, want everybody for their trade cycle and then pitch them all out, and maybe they want to get absorbed in industry adjacent to such a factory which has a trade cycle in a different part of the year. I rather feel that I have covered your points and I would like to quote one example of a firm being able to find labour. Take Ford's of Dagenham. You know the factory, and you know what was there when Ford's first went there. I think these people showed amazing courage in developing a factory on such a marshy site as that was, and I think all praise is due to them in developing such a factory there. When they went there, there was no labour, but the place is now a prosperous township simply on account of Ford's factory going there. Our own factory is another case. When our factory was put there, there was very little in the way of a bus service, it was a mile or two away from the nearest station, and there were very few houses in the district. Now there are plenty of houses and the district has much improved services. I rather feel that the labour point of view can be over-emphasised. If you look around you can find a number of factories that have started in bad areas from a labour point of view and have got over those difficulties.

MR. SPENCER: I would like to refer to the proximity of goods inwards department to goods despatching department mentioned earlier. Do you consider it is more important to have these two departments together than to shorten the production line? Say a factory is normally rectangular shape. You have goods inwards in one corner. Goods flow in and they move to the top of the production line. If you have the despatch department close to the goods inwards department it means they have got to come all to way back. If you have the despatch department at the opposite end they go straight out. Do you consider it more important to bring the goods all the way back than to shorten the production line?

MR. PUCKEY: To quote an extreme case, I should say that that the shortening of the production line might be a more important consideration than joint receiving and despatch supervision, but I am not prepared to say that you could not design a layout that would embody the two. I have an example in mind at the present time. You have a long loading bank extending along the factory. You have the goods coming in at the receiving portion on the loading bank, going into the stores and into the shop, finding their way around, and back towards the other portion of the loading bank by the despatch department. The whole scheme arranged under one superintendent who controls both the receiving and despatching, receiving at one end, despatching at the other, and you automatically

get your flow and at the same time you get the supervision. If things could not be fitted in, however, I think perhaps the shortening of the production line would be the more important.

A vote of thanks to Mr. Puckey, proposed by Mr. Bedford, was cordially adopted.